REMARKS

This amendment is being filed in response to the Office Action ("the Action") mailed May 24, 2010. Reconsideration of the application is respectfully requested. Claims 1-16 were previously cancelled. Claims 17-39 were pending and rejected. Editorial amendments have been made to the claims. These amendments are fully supported by the specification; no new matter is added. For reasons set forth below, Applicants submit the amendments place the application in condition of allowance.

Rejection of Claims 17-23 under 35 U.S.C. § 103(a)

In "Claim Rejections - 35 USC § 103" on pages 3-6 of the Action, claims 17-23 were rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 5,933,146 to Wrigley (hereinafter "Wrigley") in view of U.S. Patent No. 6,597,359 to Lathrop (hereinafter "Lathrop"). However, because at least one element of the claims is not taught nor suggested by the combination of Lathrop and Wrigley, Applicants therefore respectfully argue that the Action fails to make a *prima facie* case of obviousness.

Rejection of Claims 17-23

Independent claim 17, as amended, recites, in part:

> traversing, by the computing device, a ray through the acceleration structure until an object of intersection with the ray is identified;
> performing a first intersection computation between the object of intersection and the ray;
> *storing, by the computing device, the object of intersection in a list of objects that have been intersected by the ray;* and
> after the object of intersection is stored in the list:
> searching the list, by the computer device, for the object.
> and
> *preventing, by the computing device, further performing of intersection computations between the object and the ray after performing the first intersection computation.*

[Emphasis added.] As discussed previously, the Application describes the use of a "list unit" and a "mailbox" that record object information for a ray as the ray is being traced. Thus, as the ray is being traced, the list unit and mailbox stores objects *as the ray intersects them* and prevents future intersections from being computed with the objects *for that ray*:

> For purposes of further optimization, a decision unit is used that prevents objects or triangles that have already been intersected by a ray cast during ray tracing from being intersected by the ray again. This is effected by expanding the list unit by a mailbox, as shown in FIG. 2. *When a ray is cast, this mailbox notes which objects or triangles the ray intersects and prevents any one triangle or object from being intersected more than once by the ray. As a result, fewer ray-object, i.e. ray-triangle, intersection computations need to be carried out, and this accelerates the computation.* The mailbox may be seen as a kind of intersection-computation cache, which, unlike a memory cache, does not prevent memory requests to the memory but prevents intersection computations instead.

[Application, at page 11, last paragraph.] Applicants respectfully submit that Wrigley and Lathrop either separately or in combination, do not teach or suggest the above-emphasized language of claim 17.

Neither Wrigley and Lathrop teach or suggest "storing, by the computing device, the object of intersection in a list of objects that have been intersected by the ray" as recited in claim 17. In its rejection of claim 17, the Action cited to Fiugre 6 of Wrigley as "storing . . . the object of intersection in a list," and in particular cited to Wrigley's "internal tree representation." [Action, at § 5, page 3.] While Figure 6 does appear to discuss an "internal tree representation," Applicants note that this representation is created *before* it is determined which objects are interested by a ray:

> Thus, in the example shown in FIG. 6, *the process of determining whether a primary path projected from a point directly above the plane of FIG. 6 will intersect the object* contained in the envelope 46 involves the initial stage of determining whether the path intersects the envelope 50. *If no such intersection occurs* the path is disregarded because it cannot intersect the envelope 46, *but if there is such an intersection* the question of whether the path also intersects the envelope 53 is then considered. . . . .

> *The internal tree representation of FIG. 6 shows the various alternatives which arise when analysing a given primary path* in relation to any of the objects.

[Wrigley at column 6, lines 53-67; emphasis added.] Applicants respectfully note that, as the passage shows, the "internal tree representation" structure described by Wrigley at Figure 6 is created *before* intersections are computed between a ray and any objects. As such, the "internal tree representation" contains both objects that are intersected by a given ray and objects that are not intersected – it is the job of the "internal tree representation" to help determine which objects are which.

The "internal tree representation" of Wrigley therefore cannot teach or suggest "storing, by the computing device, the object of intersection in a list of objects that have been intersected by the ray." The "internal tree representation" is not a "list of objects that have been intersected by the ray" as it contains objects regardless of whether they are known to be intersected by the ray. Further, because Wrigley's objects are stored *before* it is known if they are stored, Wrigley does not teach or suggest "storing, . . . the object of intersection" as it cannot know at the time of storage whether a given object is an "object of intersection."

Lathrop does not remedy this deficiency of Wrigley. Lathrop's directed acyclic graph, ("DAG") which is cited to in the Action, contains nodes directed to portions of space. [Lathrop, at column 7, lines 57-62.] However, the Action argued that Lathrop teaches nodes which contain a single object. [*See*, Action, at §2, page 2.] This argument of the Action is discussed in further detail below.

Notwithstanding this argument, Applicants still contend that Lathrop's ("DAG") does not teach or suggest "storing, by the computing device, the object of intersection in a list of objects that have been intersected by the ray," as recited in claim 17. Lathrop describes looking up portions of space already stored in the DAG to determine whether the portion of space (and potentially objects stored in that portion) will be intersected:

> *In a further refinement of the invention, the apparatus includes a means that can determine the sequence of scene sub-spaces traversed by a ray, and generate the sequence of corresponding DAG leaf nodes. . . .* In that case, the apparatus generates a sequence of memory addresses, which

> refer to the DAG leaf nodes, which correspond to the scene subspaces traversed in order by a ray.
>
> This is illustrated in FIG. **6** . The apparatus determines that subspaces B, C, and D, in that order, are traversed by ray **30** . The apparatus therefore generates references to the DAG leaf nodes **23** , **24** , and **25** in that order. . . .
>
> . . .
>
> *In a further refinement of the invention, the apparatus includes a means that can determine whether any ray could ever intersect a particular scene object within the scene volume represented by a particular DAG node.* In the absence of such a means, this determination would have to be performed externally to the apparatus if dynamic subdivision is employed. *Note that this determination is essentially an intersection check between the node's scene subvolume and the scene object.*

[Lathrop, at column 8, lines 23-62; emphasis added.] As these passages show, Lathrop's DAG is consulted to determine what intersections *might* occur, similarly to the way Wrigley uses its "internal tree representation" discussed above. As such, Applicants respectfully submit that Lathrop does not teach or suggest "storing, by the computing device, the object of intersection in a list of objects that have been intersected by the ray," as recited in claim 17.

Lathrop's directed acyclic graph, which is cited to in the Action, does not teach "storing . . . the object of intersection in a list of objects that have been intersected by the ray" as recited in claim 17. In its rejection, the Action cites to Figures 4-9 and column 7, lines 57-62 of Lathrop. [*See*, Action, at § 5, page 4.] As Applicants previously argued, the DAG cited to by the Action consists of nodes which represent spaces or areas. [*See,* Applicants' Amendment and Response of February 23, 2010.] As Applicants argued, Lathrop's nodes themselves clearly *do not* themselves represent objects. However, the instant Action also argued that Lathrop teaches that nodes may be "subdivided until [an object] is represented by a single node" at column 9, lines 28-30.

The passage of column 9 describes that "[i]f the number of objects referenced by the node is more than a predetermined threshold then subdivide." [Lathrop, at column 9, lines 28-30.] Applicants respectfully note, however, that, notwithstanding the Action's

interpretation of Lathrop, the act of repeatedly subdividing a node *does not* mean that an object will be represented by a single node. Instead, performing this action will at best result in there being no more than one object per node. However, this is not the same as there being one node per object, which is what the Action argues.

Figure 5 offers an example of this distinction. In Figure 5, nodes representing spaces D and B each have only one object contained in them, while the node representing space C has parts of three objects in it. If the spaces were to be subdivided as suggested in the Action, using a threshold of 1 object, only node C would be subdivided. However, even if C were subdivided until its subnodes each represented only one object, those objects would not necessarily be represented by only one node. Specifically, objects 27 and 28 would have some portion represted by nodes D and B, respectively, while some other portion would be represented by subnodes of node C.

For at least these reasons, even if one of Lathrop's nodes is subdivided to represent only one object, Lathrop, does not teach or suggest "storing . . . the object of intersection in a list of objects that have been intersected by the ray" as recited in claim 17.

Lathrop's space-based graph does not prevent objects from being intersected with a node more than once, and cannot teach "preventing, by the computing device, further performing of intersection computations between the object of intersection and the ray after performing the first intersection computation" as recited in claim 17. As Figures 5, 8, and 9 of Lathrop illustrate, and as discussed above, an object may be found in more than one space. This is true even if Lathrop subdivides nodes to prevent a node from representing more than one object, as discussed above. Thus, even if Lathrop's DAG were considered to read on the "storing . . . the object of intersection in a list of objects that have been intersected by the ray" language of claim 17, the storage of an object cannot necessarily "prevent[] . . . further performing of intersection computations between the object of intersection and the ray after performing the first intersection computation" as recited in the claim language.

For at least these reasons, the rejection of claim 17 failed to establish a *prima facie* case of obviousness over Wrigley and Lathrop. Claim 17 should be allowable over Wrigley and Lathrop. Additionally, while Applicants do not individually belabor the rejections of dependent claims 18-23, Applicants note that each claim recites, based on independent claim 17, at least one element not shown in Wrigley and Lathrop for the reasons discussed above. Claims 17-23 are thus allowable over Wrigley and Lathrop. Applicants respectfully request that the rejection of claims 17-23 under § 103(a) be withdrawn and that claims 17-23 be allowed.

Rejection of Claims 24-29 and 32-38 Under 35 U.S.C. 103(a)

In "Claim Rejections - 35 USC § 103" on pages 7-12 of the Action, claims 24-29 and 32-38 were rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 5,933,146 to Wrigley (hereinafter "Wrigley") in view of U.S. Patent No. 6,597,359 to Lathrop (hereinafter "Lathrop").

Independent claims 24 and 32 each recite language similar to that discussed above with respect to claim 17. Claim 24, as amended, recites:

> a decision unit operatively configured such that, when ray-object intersection data has been computed for a given ray and a given object, the decision unit records that the given ray has intersected the given object and prevents additional ray-object intersection computations from being carried out for the given ray and the given object.

Claim 32, as amended, recites:

> for a given ray, and for an object for which an intersection computation has been performed with the given ray:
>
> record that the intersection computation has been performed for the given ray and the object; and
>
> prevent further performing of intersection computations between the object and the given ray.

In its rejection of the above-quoted language of claims 24 and 32, the Action noted similar deficiencies in Wrigley as those discussed above with respect to claim 17, and cited to the same passage of Lathrop. [*See*, Action, at pages 7 and 10.] Thus, for at least

the reasons discussed above with respect to claim 17, the rejections of claims 24 and 32 failed to establish a *prima facie* case of obviousness over Wrigley and Lathrop. Claims 24 and 32 should be allowable over Wrigley and Lathrop. Additionally, while Applicants do not individually belabor the rejections of dependent claims 25-29 and 33-38, Applicants note that each claim based on independent claims 24 or 32, at least one element not shown in Wrigley and Lathrop for the reasons discussed above. Claims 25-29 and 33-38 are thus allowable over Wrigley and Lathrop as well. Applicants respectfully request that the rejection of claims 24-29 and 32-38 under § 103(a) be withdrawn and that the claims be allowed.

Rejection of Claims 30, 31, and 39 Under 35 U.S.C. 103(a)

Claims 30, 31, and 39 were rejected under 35 U.S.C. § 103(a) over Wrigley in view of Lathrop and further in view of U.S. Patent Application Publication No. 2004/0233222 to Lee et al. (hereinafter "Lee"). [*See*, Action, at pages 12-15.]

It is respectfully submitted that Lee does not make up for the lack of teaching in Wrigley and Lathrop as described above. Therefore, independent claim 24 remains allowable over Wrigley and Lathrop even when combined with Lee. Claims 30 and 31 depend from claim 24; for at least similar reasons to those discussed above, claims 30 and 31 are allowable over the cited references.

Claim 39 recites, in part:

> the decision unit configured to prevent objects whose object addresses are stored in the list from being intersected again by the ray . . . .

In its rejection of the above-quoted language of claim 39, the Action noted similar deficiencies in Wrigley as those discussed above with respect to claim 17, and cited to the same passage of Lathrop. Claim 39 is thus allowable over Wrigley and Lathrop. And, as with claims 30 and 31, Lee does not make up for the lack of teaching in Wrigley and Lathrop. Therefore, claim 39 remains allowable over Wrigley and Lathrop even when combined with Lee.

Applicants respectfully request that the rejections of claims 30, 31, and 39 under 35 U.S.C. § 103(a) be withdrawn and that the claims be allowed.

CONCLUSION

In view of the foregoing, allowance of pending claims are solicited. If the Examiner has any questions concerning the present paper, the Examiner is kindly requested to contact the undersigned at (503) 796-2446. If any fees are due in connection with filing this paper, the Commissioner is authorized to charge the Deposit Account of Schwabe, Williamson and Wyatt, P.C., No. 500393.

Respectfully submitted,
SCHWABE, WILLIAMSON & WYATT, P.C.

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